IDF Curve Tool

In the IDF Curve tool, you have two options for inputting data. The first option allows you to input raw data, and the tool will use it to create a Rainfall Intensity Table. The second option enables you to directly input the Rainfall Intensity Table. Therefore, we will assume that you are inputting raw data, and the other option is a subset of the first option.

Step1: If you input a 5-minute rainfall time series, the tool can calculate rainfall time series for various time scales, including 5 minutes, 10 minutes, 15 minutes, 30 minutes, 1 hour, 2 hours, 3 hours, 6 hours, 9 hours, 12 hours, 18 hours, and 24 hours. However, if you input hourly data, the tool will calculate rainfall data for 1 hour, 2 hours, 3 hours, 6 hours, 9 hours, 12 hours, 18 hours, and 24 hours only.

If we have hourly data and we need to calculate 3-hour rainfall you should define overlapping 3-hour periods. These overlapping periods ensure that you capture the complete dataset without gaps. For example, if you have hourly data from 00:00 to 23:00, your 3-hour periods might look like this:

Period 1: 00:00 - 03:00

Period 2: 01:00 - 04:00

Period 3: 02:00 - 05:00

...and so on.

By defining overlapping periods, you can calculate the intensity for each 3-hour segment in your dataset without missing any data points.

Step2: Following this step, the tool will compute maximum values. Users have the option to select from various maximum calculation options, including yearly maximum, maximum for a specific month, maximum for one of the twelve predefined seasons, or maximum based on a custom selection of months. The twelve predefined seasons are:

DJF: December, January, February (Winter)

JFM: January, February, March (Winter to Spring transition)

FMA: February, March, April (Early Spring)

MAM: March, April, May (Spring)

AMJ: April, May, June (Late Spring)

MJJ: May, June, July (Early Summer)

JJA: June, July, August (Summer)

JAS: July, August, September (Summer to Autumn transition)

ASO: August, September, October (Early Autumn)

SON: September, October, November (Autumn)

OND: October, November, December (Late Autumn)

NDJ: November, December, January (Autumn to Winter transition)

Step3: The maximum values for any time scale are included as elements in the Rainfall Intensity Table, which can be found in the second tab of the tool.

Step4: Now we can calculate IDF for each time scale. IDF curves can be constructed through frequency analysis. This process employs various statistical distributions such as Extreme Value Type I, Gamma, Exponential, Log-Normal, and Weibull distributions for rainfall frequency analysis. To generate these curves, the procedure involves extracting annual maximum rainfall depths from historical rainfall records for each selected duration (as described above). Subsequently, frequency analysis is conducted on the extracted annual data.

Firstly, it is important to fit the desired distribution and determine its distribution parameters. The inverse cumulative distribution function (CDF) of the chosen

distribution provides the Intensity-Duration-Frequency (IDF) values for any given probability. The probability can be calculated using the following formulas:

$$P = 1 - \frac{1}{T}$$

To utilize the distribution functions, we rely on the Accord.Statistics library, and the formulas for each distribution are provided below:

1- **Empirical Plotting Position**

To demonstrate the first approach, consider, for instance, the 30-minute duration data follow these steps:

1) Arrange the observations in descending order

2) Calculate the exceedance probability for each rainfall volume using the following expression:

p = 1 / T = Rank / (m + 1)

where m represents the number of observations, p is the exceedance probability, and T corresponds to the return period

3) Convert the volume data into rainfall intensity by dividing the volume by the corresponding duration.

4) Generate an empirical distribution of rainfall intensity.

As noted, repeat this procedure for each desired duration.

2- Theoretical Extreme Value

We are using the Gumbel (Type I) distribution as our Extreme Value (EV) distribution. The Gumbel Type I distribution is:

$$G(X:\mu,\beta) = \frac{1}{\beta} e^{\frac{X-\mu}{\beta}} e^{-e^{\frac{X-\mu}{\beta}}}$$

Here, μ represents the location parameter, and β is the scale parameter.

Reference: Extreme Value Type I Distribution

3- Gamma Distribution

There is a well-established history of modeling daily precipitation using a gamma distribution. The gamma distribution, often employed to characterize temporally averaged precipitation statistics, is defined as follows:

$$f(x) = \frac{1}{\Gamma(x)\theta^k} x^{k-1} e^{-\frac{x}{\theta}}, \qquad x > 0$$

In this distribution, k represents the shape parameter, θ stands for the scale parameter, and x represents the rainfall.

Reference: Gamma distribution

4- Exponential Distribution

5- Certainly, the exponential distribution is the most straightforward member of the gamma family of distributions and can be viewed as a specific instance of the two-parameter gamma distribution. It is characterized by a single parameter and has been extensively applied in the fields of hydrology and water resources. The exponential distribution is commonly employed for frequency analysis of rainfall depth, intensity, duration, and the number of rainfall events (Eagleson, 1982). The probability density function is provided below:

$$f(x) = \lambda e^{-\lambda x}\ , \quad x \geq 0$$

In this context, $\lambda > 0$ serves as the distribution's parameter, often referred to as the rate parameter. This distribution is defined over the interval [0, ∞), and for values of x less than 0, the probability density is equal to 0.

Reference: [Exponential distribution]

6- **Weibull Distribution**

The Weibull distribution is a continuous probability distribution used to model a wide array of random variables, particularly those related to time-to-failure or time between events.

$$f(x{:}\,\lambda,\kappa) = \frac{k}{\lambda}\left(\frac{x}{\lambda}\right)^{k-1} e^{-(\frac{x}{\lambda})^{k}},\quad x \geq 0$$

In this context, k > 0 represents the shape parameter, while λ > 0 represents the scale parameter of the distribution. Additionally, for values of x less than 0, the probability density is equal to 0.

Reference: Weibull distribution

7- Log-normal Distribution

There is substantial empirical evidence suggesting that the characteristics of rain tend to exhibit an approximate lognormal distribution. What's even more intriguing is that when it comes to area averages of rain rate, they tend to conform to a lognormal distribution rather than the "expected" normal distribution.

$$f(x) = \frac{1}{x\sigma\sqrt{2\pi}} \exp\left(-\frac{(\ln(x)-\mu)^2}{2\sigma^2}\right)$$

This is the probability density function of the log-normal distribution with parameters μ and σ. It's important to note that these parameters, μ and σ, represent the expected value (or mean) and standard deviation of the natural logarithm of the variable, not the mean and standard deviation of the variable X itself.

Reference: Log-normal distribution